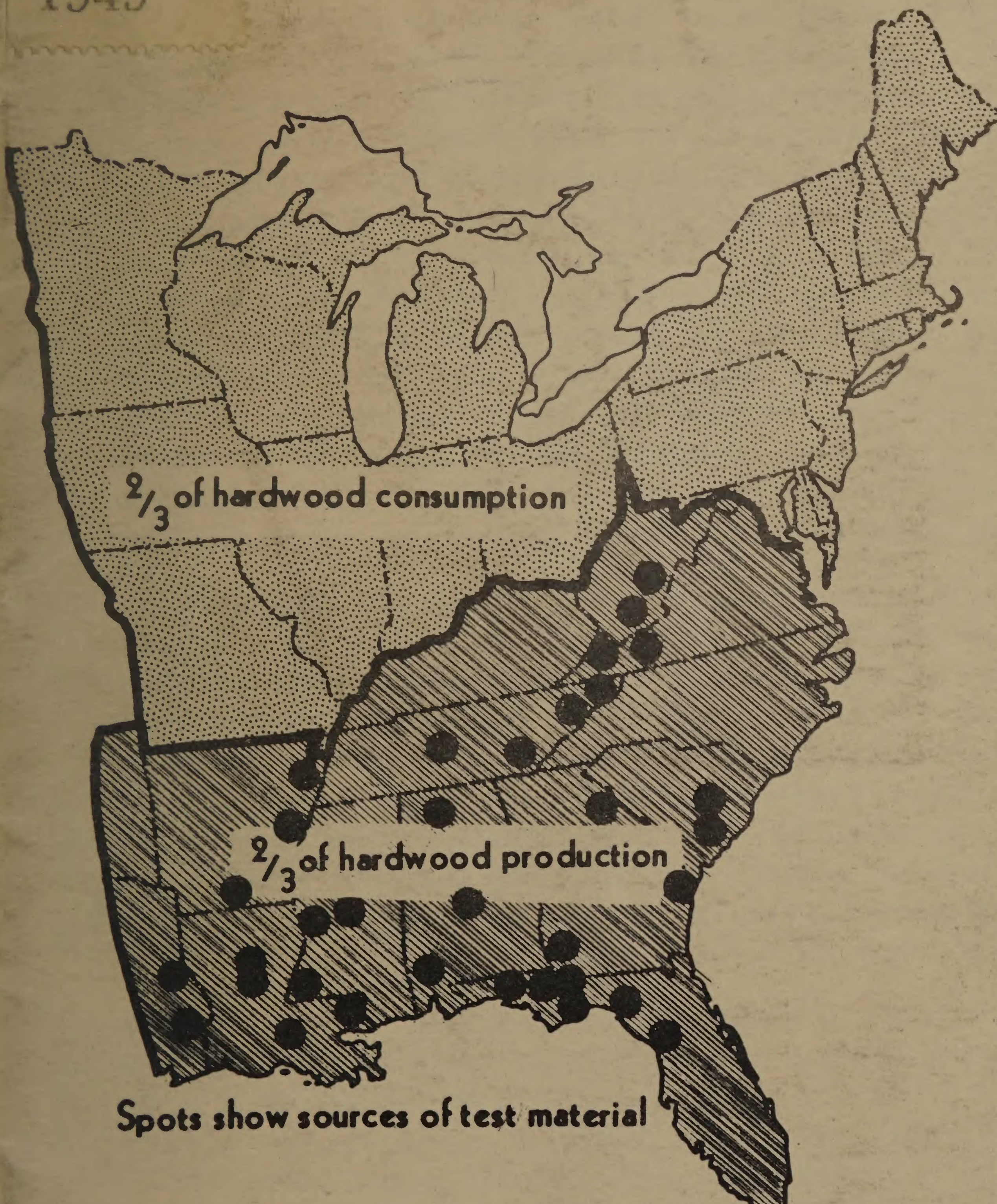
HARDWOODS of the South



texture
planing
shaping
turning
bending
warping
cross grain
treating
splitting
nail holding
screw holding
gluing
odor & taste

Forest Products Laboratory, Madison, Wis.

Forest Service.

U.S. Department of Agriculture

1949

UNITED STATES

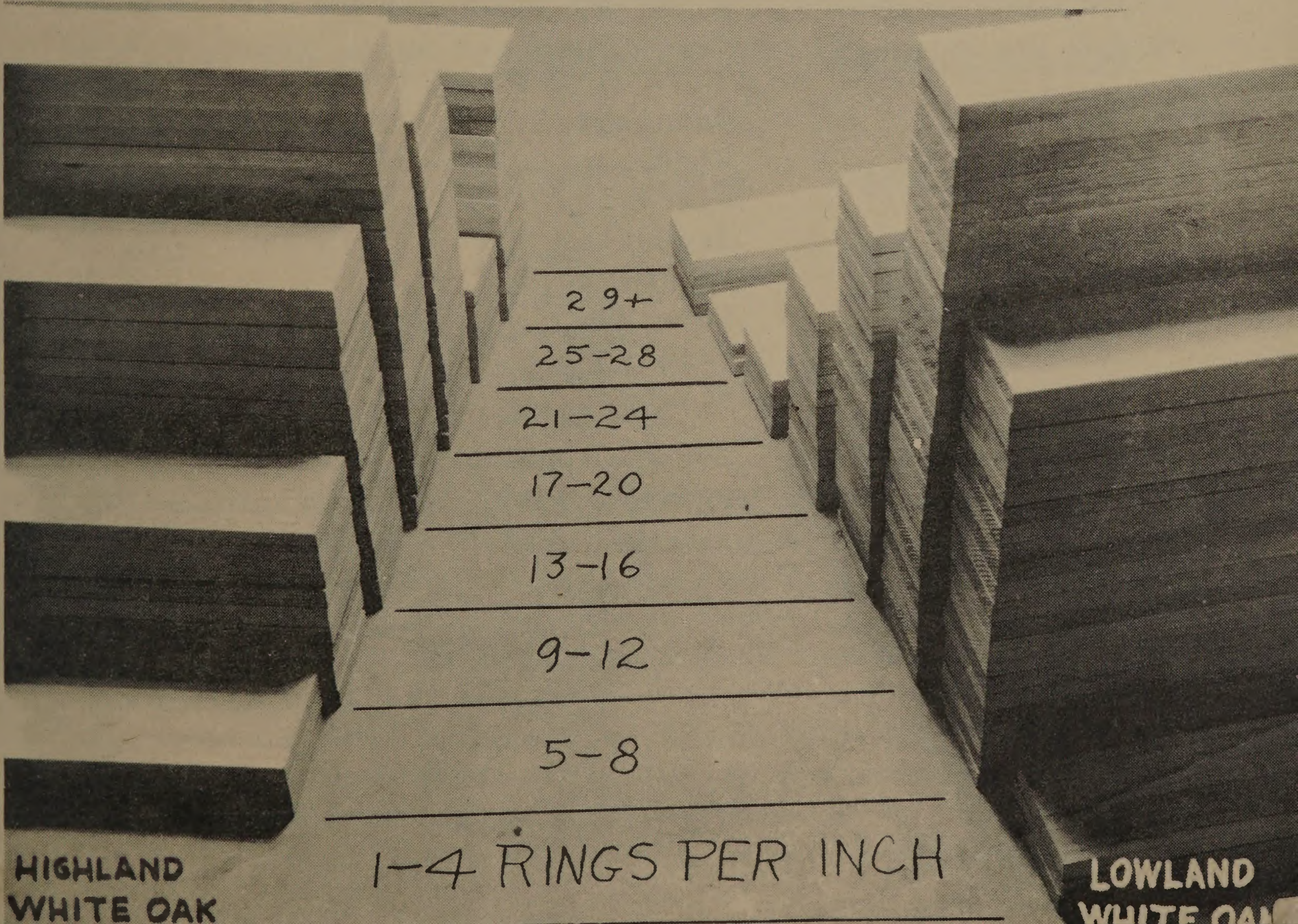
TO MANY CON [illegible] m the South are ne [illegible] these woods were nc [illegible] wood-working factc [illegible] w; but when their ch [illegible] igated and understoc [illegible] way to emphasis on l [illegible] eabil-ity. Geograpl [illegible] y held by consumers [illegible] ent by producers) as [illegible] on quality. Local growth c [illegible] tions do have a marked effect on quality, but geogr [illegible] in itself is a poor index of growth conditions, an [illegible] the Forest Products Laboratory in its years of testing and research is inclined to minimize the importance or reliability of adhering strongly to state or regional distinctions.

Some of the everyday working qualities and machining characteristics of southern hardwoods have been under study at the Forest Products Laboratory during recent years. A wide range of territory is represented in the collection of material used in these tests. Much of the data briefly summarized in the pages that follow deals with properties that, although of an eminently practical nature and basic to satisfactory wood use, nevertheless have never before been systematically explored in the case of any American woods.

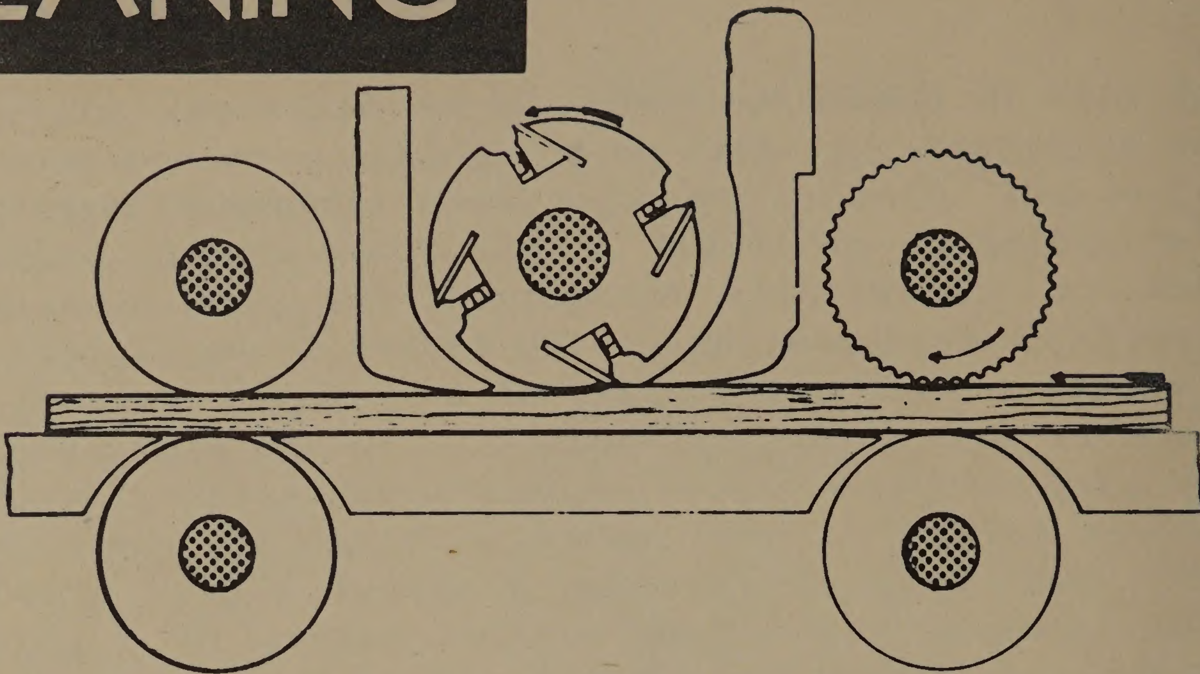
In the case of most properties and woods the results obtained depend on how a process is carried out as much as on the wood itself. Work on southern hardwoods to date has dealt only with inherent species characteristics. Later on attention will be directed to the working out of allowances or of methods of compensating for inherent species characteristics.

TEXTURE

VARIABILITY IN LUMBER as produced by different mills is not to be denied. It must be recognized more and more as time goes on. Pending the time when systems of segregation according to qualities of the clear wood as well as defects are commercially recognized, the buyer must know the growth characteristics of the timber if he is particular about what he gets. East of this river or west of that one is no criterion of quality. In the highlands as in the lowlands some timber stands produce fine-textured and others coarse-textured lumber, although the old-growth highland oak is on the average somewhat slower growing than the lowland oak. When typical pieces of highland white oak are sorted into piles according to number of rings per inch, the result is as shown at the left below, whereas an equal number of typical pieces of lowland white oak fall into the arrangement on the right. It is significant that there is 55 percent of material in the highland oak similar to that in the lowland oak and vice versa. However, the bulk of the highland oak is in the tiers of 17 or more rings per inch, and the bulk of the lowland oak is in tiers of 16 or less rings per inch. In the case of second growth from the two regions, there is less difference in the average ring width.



PLANING

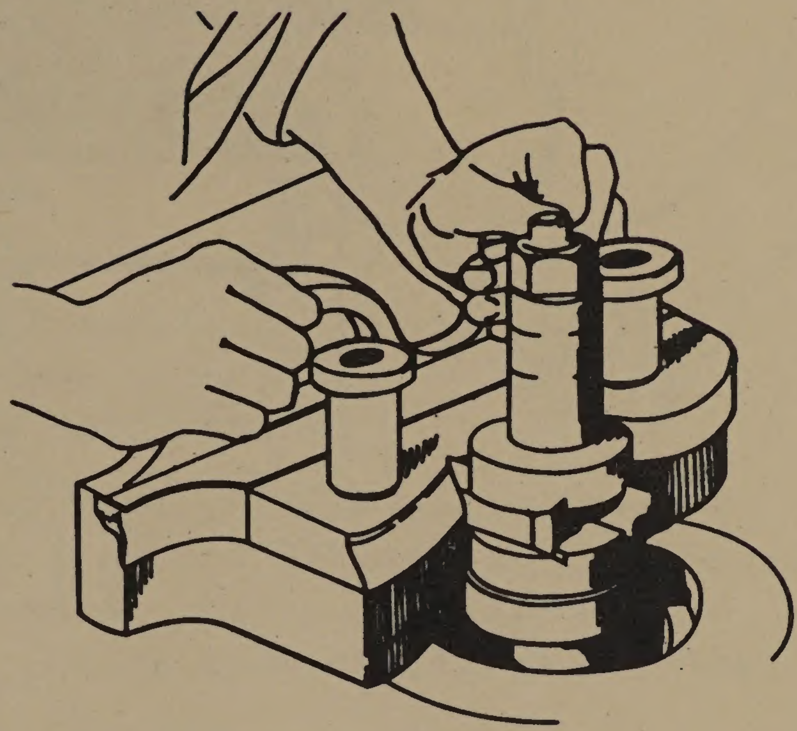


ALMOST ANY WOOD can be planed well if the conditions of speed, moisture content, cutting angle, etc., are right. But some woods must be handled just so, while for others good results are obtainable under a wide range of conditions. Contrary to a popular opinion, high cutterhead speed (5,400 r.p.m. and 54-feet feed per minute) seems to give better results than the common speed of 3,600 r.p.m. and 36-feet feed per minute. With a 30-inch cabinet planer and four jointed knives at a 30° angle, the following classification results as regards difficulty in avoiding pitmarks and chipped, raised, or fuzzy grain.

Least difficult	Intermediate	Most difficult
Ash	Basswood	Cottonwood
Chestnut	Birch	Elm
Hackberry	Blackgum	Maple, soft
Mahogany	Magnolia	Sycamore
Oak, red	Maple, hard	
Oak, white	Sweetgum	
Oak, chestnut	Walnut	
Pecan	Willow	
Yellow-poplar		

The above conditions, while typical of much commercial practice, are not the optimum for every wood. Best trade experience already points to more favorable planing conditions for most of these woods. Planing conditions can probably ultimately be so adjusted as to give almost perfect results even on the woods in the most difficult group. But just what these adjustments are, has not yet been established; and to establish them would involve a large amount of precision testing which thus far has never been done for wood.

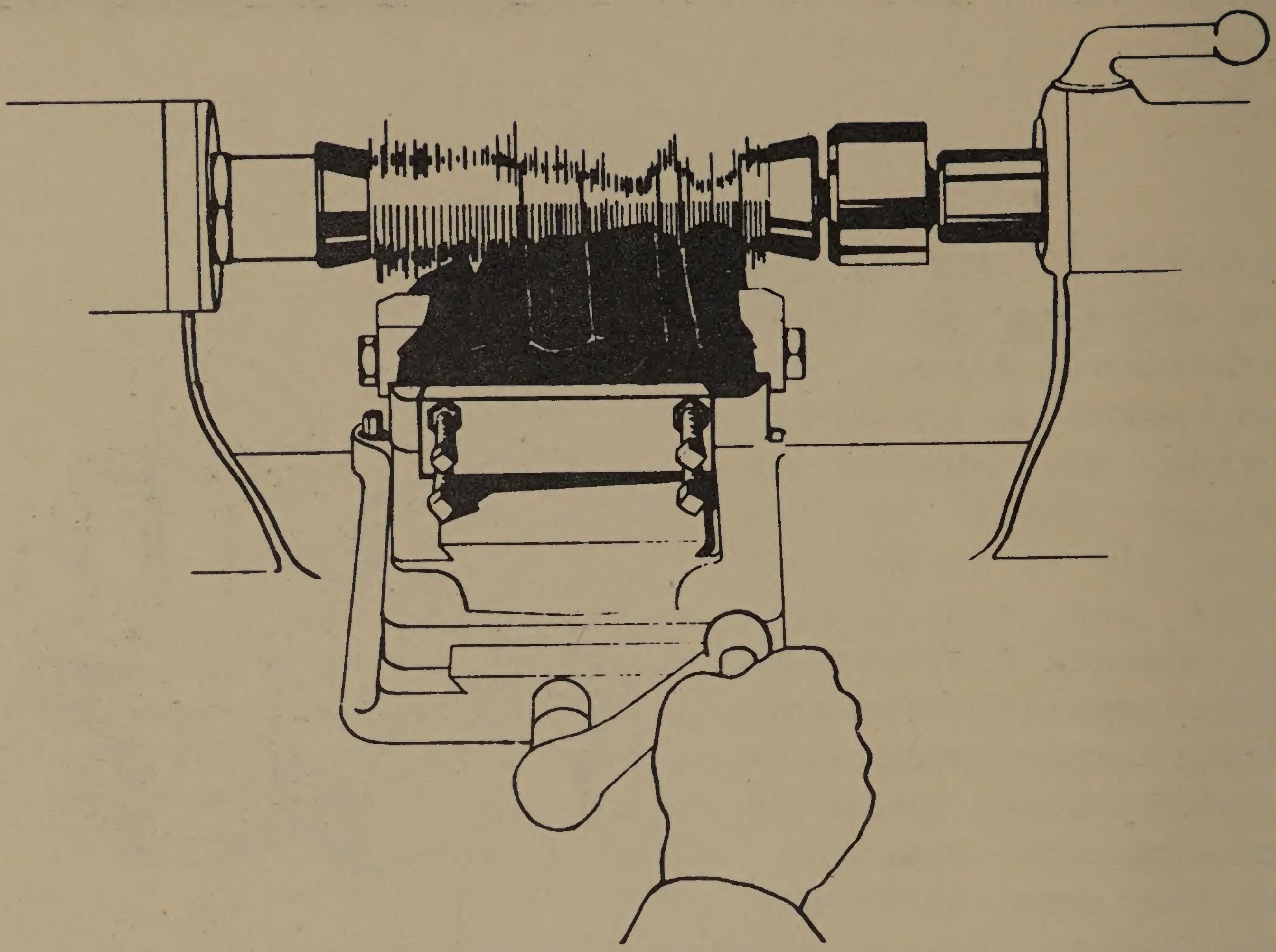
SHAPING



SHAPING IS ONE of the more exacting machining operations. Almost any wood makes a passable showing when shaped at a slight angle to the grain. It is in shaping across the end grain that the big differences between species show up. Further experiments will no doubt reveal means of improving the results with the more difficult woods. Meanwhile, preliminary tests group the woods as shown below, with smoothness of cut and absence of splintering or chipping being the governing considerations. The shaper used was of the standard two-knife type running at a typical commercial speed of 7,200 r.p.m.

Least difficult	Intermediate	Most difficult
Ash	Beech	Basswood
Birch	Blackgum	Buckeye
Mahogany	Chestnut	Cottonwood
Maple, hard	Hickory	Elm
Tupelo	Magnolia	Hackberry
	Maple, soft	Sycamore
	Oak, chestnut	Yellow-poplar
	Oak, red	Willow
	Oak, white	
	Pecan	
	Sweetgum	
	Walnut	

TURNING



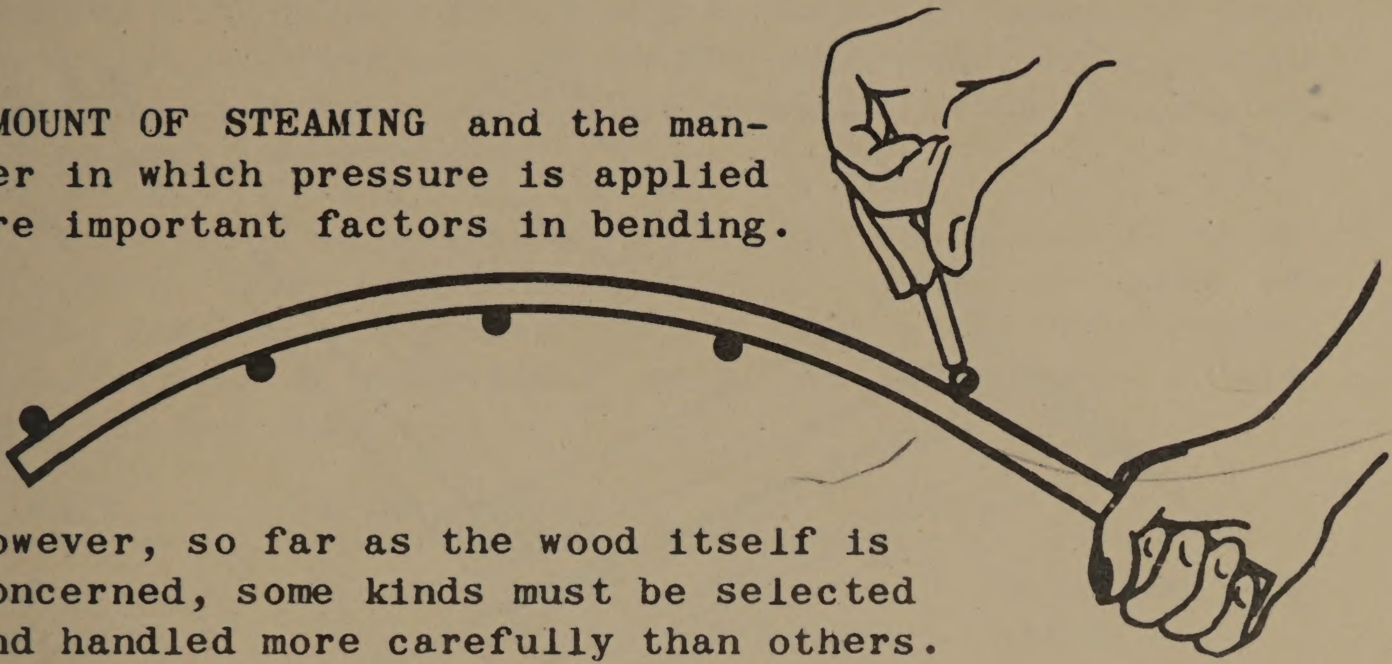
RELATIVE YIELD OF SMOOTH TURNINGS

Walnut	91	Sycamore	85	Ash	79
Beech	90	Hickory	84	Hackberry	77
Oak, chestnut	90	Oak, red	84	Maple, soft	76
Pecan	89	Maple, hard	82	Blackgum	75
Mahogany	89	Yellow-poplar	81	Cottonwood	70
Chestnut	87	Birch	80	Basswood	68
Sweetgum	86	Magnolia	79	Elm	65
Oak, white	85	Tupelo	79	Willow	58
				Buckeye	58

(Modified back-knife lathe: 6, 12, 20 percent moisture content)

SOME OF THE WOODS, like beech and pecan, turn relatively well regardless of moisture content. Other woods, like cottonwood and willow, give good turnings only if dried down to about 6 percent moisture content. In general, the heavier woods turn better than the light ones, and heavy pieces turn better than light pieces in the same wood. The main points considered in quality of turnings were general smoothness, sharpness of detail, and occurrence of broken or chipped edges, as affecting the amount of sanding that must be done to make them acceptably smooth for use.

BENDING



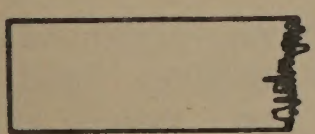
AMOUNT OF STEAMING and the manner in which pressure is applied are important factors in bending.

However, so far as the wood itself is concerned, some kinds must be selected and handled more carefully than others.

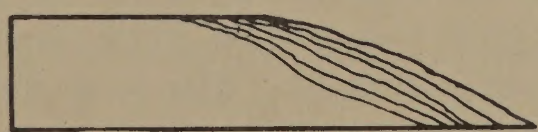
In bending 3/4-inch squares on a 20-inch radius without end pressure or any support on the outside of the bend and without selection beyond excluding knotty, unsound, or checked pieces, the following classification applies:

BENDING BREAKAGE

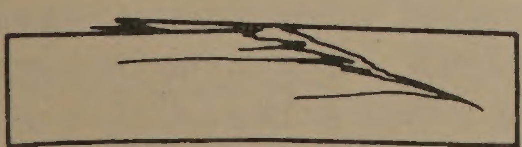
Hackberry......	6	percent	Sweetgum.......	33	percent
Oak, white.....	9	"	Maple, soft....	41	"
Oak, red.......	14	"	Yellow-poplar..	42	"
Oak, chestnut..	15	"	Maple, hard....	43	"
Magnolia.......	15	"	Chestnut.......	44	"
Pecan..........	22	"	Tupelo.........	54	"
Walnut.........	22	"	Cottonwood.....	56	"
Hickory........	24	"	Blackgum.......	58	"
Beech..........	25	"	Mahogany.......	59	"
Elm............	26	"	Sycamore.......	71	"
Willow.........	27	"	Buckeye........	91	"
Birch..........	28	"	Basswood.......	98	"
Ash............	33	"			



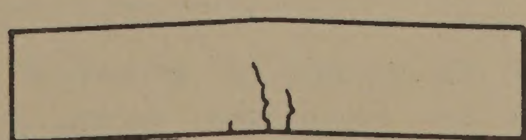
Brash break - the most common type in oak.



Cross-grain failure - not uncommon in blackgum, sweetgum, tupelo. and sycamore.

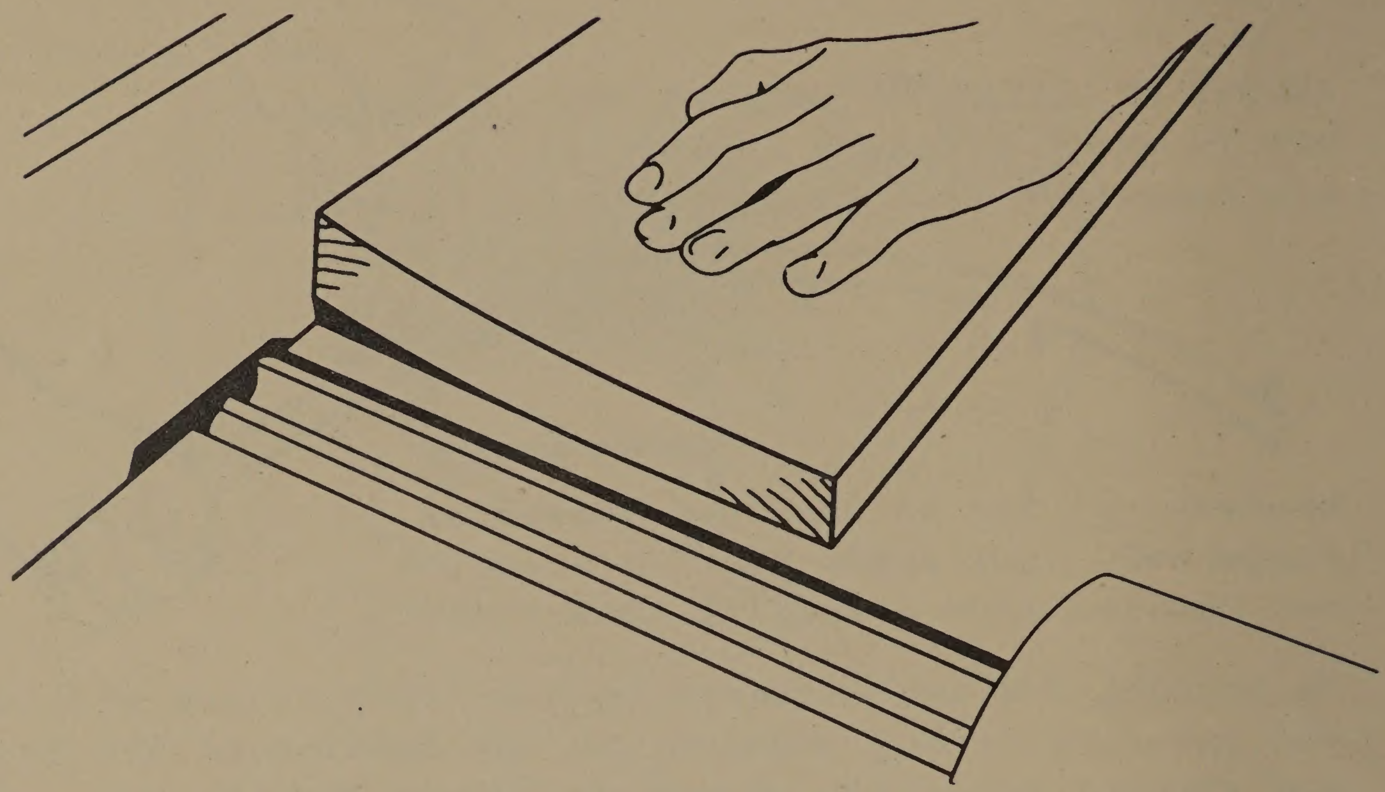


Tension failure - much the most common type in ash, elm, magnolia, soft maple, and cottonwood.



Compression failure - sometimes found in softer woods like yellow-poplar.

WARPING & CROSS GRAIN



WARPING IS CONTROLLABLE. Some species necessitate greater care to prevent warp than others; hence it is necessary to know the inherent warping characteristics of different woods. The importance of warp shows up in the amount of waste in fabrication. Twist is the most serious type of warp.

Slight warping tendencies: Ash, basswood, hackberry, oak (red), oak (white), willow.

Moderate warping tendencies: Beech, cottonwood, elm, hickory, magnolia, maple (soft), pecan, yellow-poplar.

Greatest warping tendencies: Blackgum, sweetgum, sycamore, tupelo.

The four woods of greatest warping tendencies, blackgum, sweetgum, sycamore, and tupelo, are those in which interlocked grain (the most extreme form of cross grain) is most common. Elm and cottonwood warp somewhat less and have less interlocked grain. In the remaining woods interlocked grain is rare or lacking, but spiral grain occurs to some extent in all of them. In general, woods that warp little have spiral grain with an average slope of not more than 6 percent as compared with 7 to 9 percent slope in woods of greater warping tendencies. Cross grain tends to increase warp, breakage, and defective machinework, but careful selection of material will go far to avoid dissatisfaction from this source.

DECAY & TREATING

FOR SOME USES, particularly where the wood cannot be kept dry, it is important to use either heartwood having high resistance to decay or wood that has been properly treated with a good preservative.

The sapwood of all southern hardwoods is low in decay resistance. The following grouping, which is based on service records and general experience, classifies southern hardwoods in accordance with the resistance of the heartwood to decay.

High	Intermediate	Low	
Black locust	Black cherry	Ash	Magnolia
Black walnut	Honey locust	Basswood	Maple
Catalpa	Oak, white	Beech	Oak, red
Osage-orange		Birch	Sweetgum
Red mulberry		Butternut	Sycamore
		Cottonwood	Tupelo
		Elm	Willow
		Hickory	Yellow-poplar

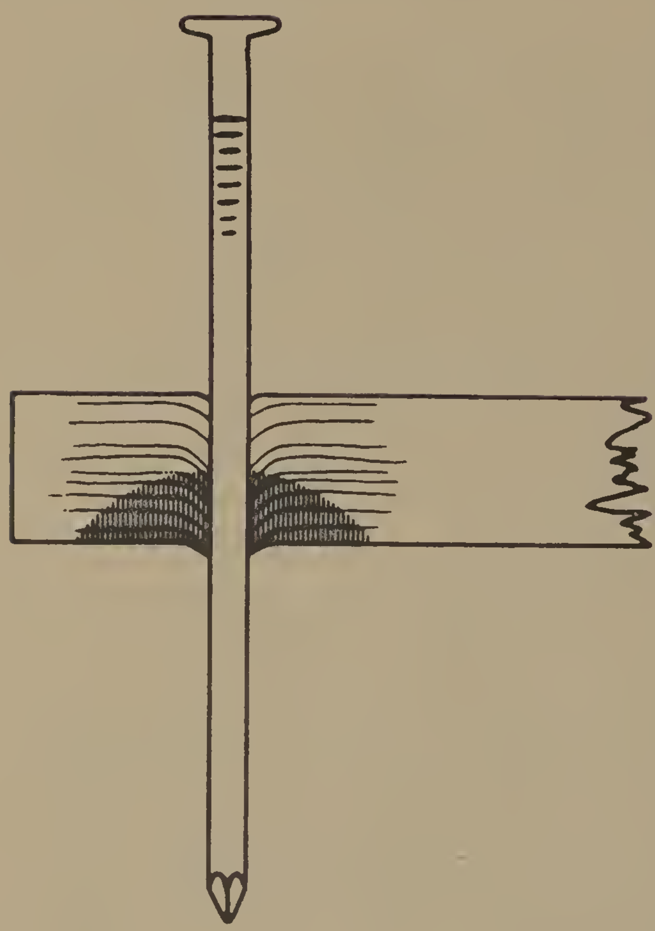
The following grouping of southern hardwoods is in accordance with the ease with which the sapwood is penetrated with preservatives under pressure.

Easily penetrated	Moderately difficult	Most difficult
Ash	Aspen	Beech (red heartwood)
Basswood	Birch, yellow	Black locust
Beech (white heartwood)	Cottonwood	Elm, rock
Birch, sweet and river	Maple	Hackberry
Elm, American and slippery	Honey locust	Oak, white
Oak, red	Willow	Sweetgum
Tupelo		Sycamore

In nonpressure treatments the heartwood of southern hardwoods is generally difficult to penetrate. The following grouping is in accordance with the kind of penetration obtained with nonpressure treatments in the sapwood.

Reasonably good penetration	Erratic penetration	
Black cherry	Ash	Hackberry
Elm, American	Basswood	Maple
Hickory, shagbark	Birch	Sweetgum
Oaks (red and white)	Butternut	Tupelo
	Cottonwood	Willow

SPLITTING IN NAILING

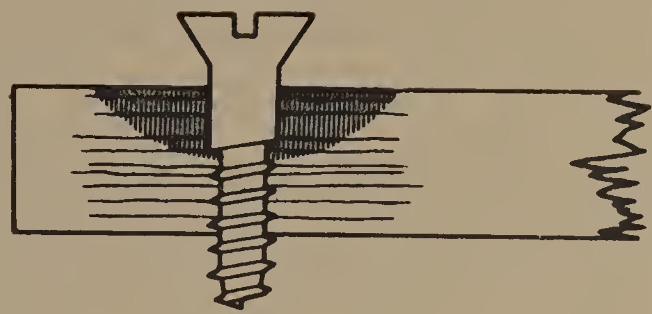


FOR BOXES AND CRATES suitability depends among other factors on the holding power of the nails, which in turn depends largely upon splitting tendencies of the species. Splitting is controlable within limits by size and spacing of nails and by the way they are driven; but even so, the kind of wood is itself a factor. Driving a nail tends to distort the fibers next to the nail downward, and this causes a downward accumulation of stress with a splitting that makes its first appearance on the under side.

Splitting tendencies of the different woods as judged by the percentage of complete splits in driving sevenpenny box nails in thin (3/8-inch) air-dry boards, close to the end (1/2 inch and 3/8 inch) are as follows:

Splits by less than 25% of nails	Splits by 25 to 40% of nails	Splits by more than 40% of nails
Basswood	Ash	Beech
Cottonwood	Blackgum	Birch, sweet
Elm, soft	Chestnut	Hickory
Sycamore	Hackberry	Maple, hard
Willow	Magnolia	Maple, soft
Yellow-poplar	Mahogany	Oak, chestnut
	Oak, red	Pecan
	Oak, white	Walnut
	Sweetgum	
	Tupelo	

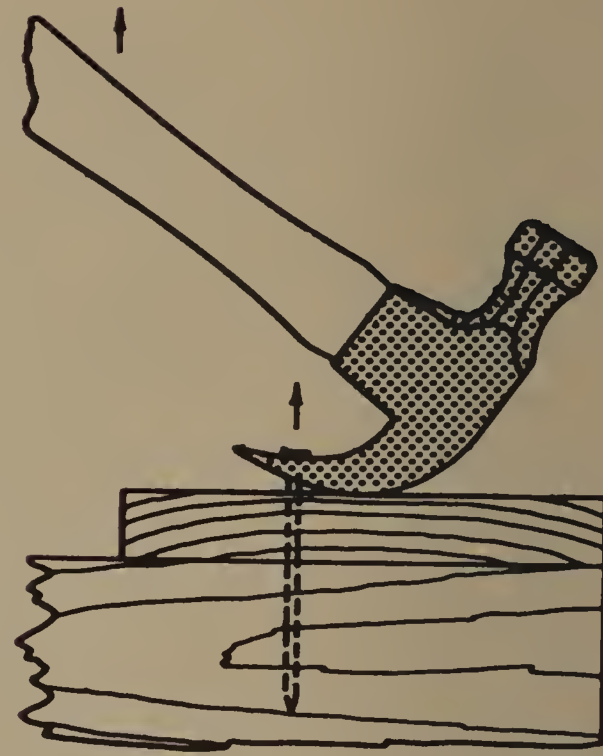
SPLITTING IN SCREWING



WITH WOOD SCREWS in drilled holes the tendency is for any splits that develop to start on the upper side of the board. The unthreaded portion just below the head exerts a wedging effect. Pronounced distortion of fibers alongside the screw is lacking. Some woods that split most readily with nails make a much better showing with screws. The classification of species that follows is based on the percentages of screws of various sizes that cause complete splits under drastic conditions, namely, in thin (3/8-inch) air-dry stock, screws driven 1/2 inch and 3/4 inch from the end.

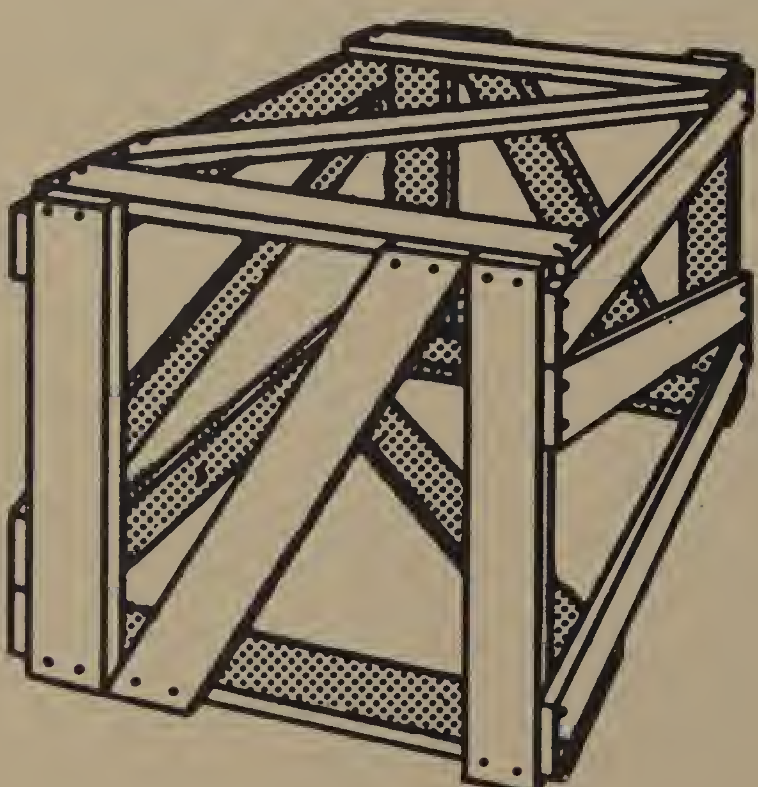
Splits by 20 to 29% of screws	Splits by 30 to 40% of screws	Splits by over 40% of screws
Ash	Basswood	Beech
Cottonwood	Blackgum	Birch, sweet
Elm, soft	Chestnut	Maple, hard
Magnolia	Hackberry	Walnut
Mahogany	Hickory	
Oak, red	Maple, soft	
Oak, white	Oak, chestnut	
Sycamore	Pecan	
	Sweetgum	
	Tupelo	
	Willow	
	Yellow-poplar	

NAIL HOLDING



FOR SOME USES the suitability of the different species of wood is largely dependent on their nail- and screw-holding ability. With this in mind, studies have been made to determine the nail- and screw-holding properties of southern hardwoods, both in resistance to direct pull and sidewise thrust.

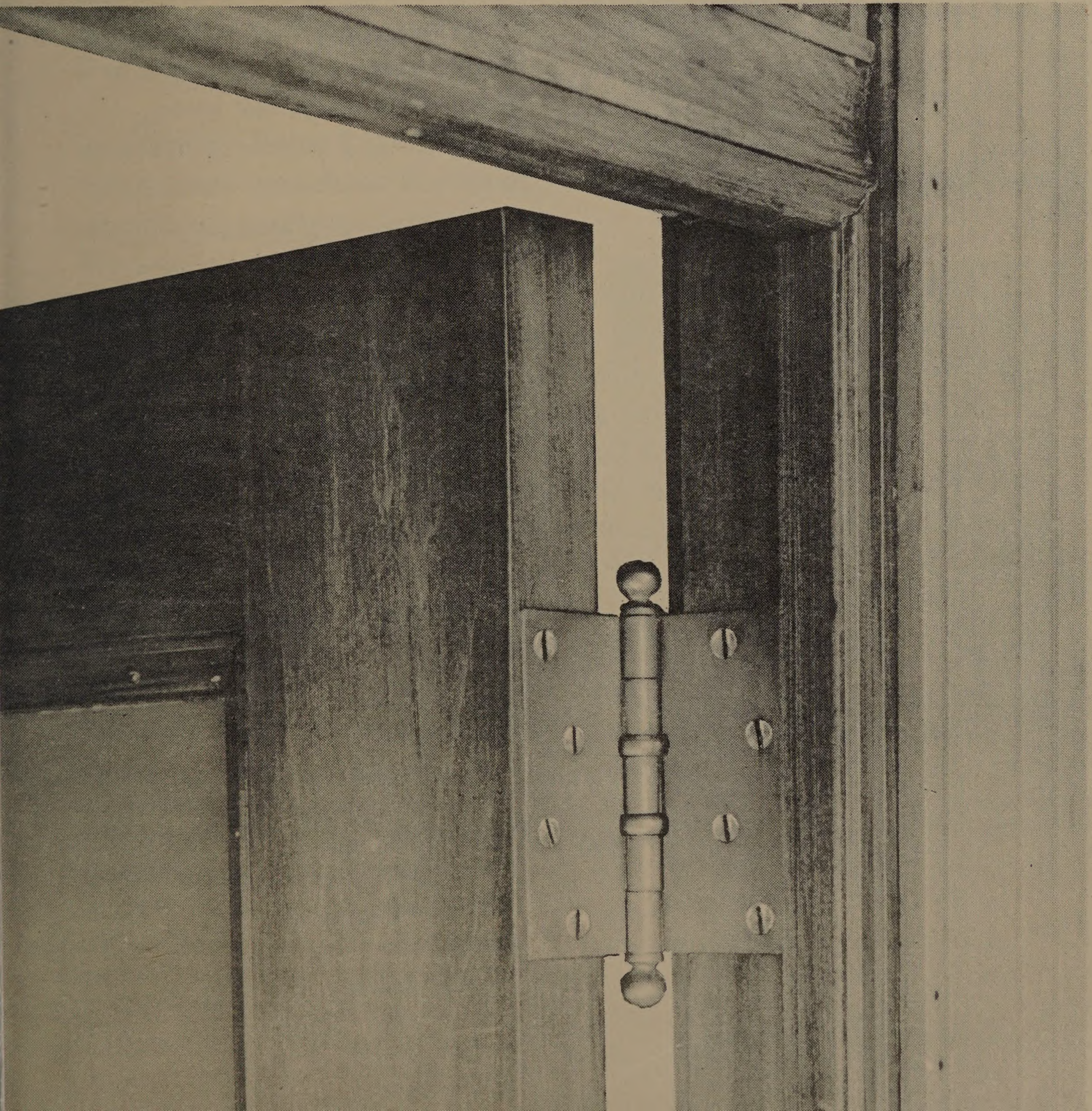
As a result of the tests made the woods have been divided into three groups, of which group 3 represents the woods of highest rank, and group 1 the lowest. The actual loads for screws and nails in the species of group 1 are from one-third to one-half those of group 3, with group 2 intermediate. The rating of the species is closely related to their density or dry weight.



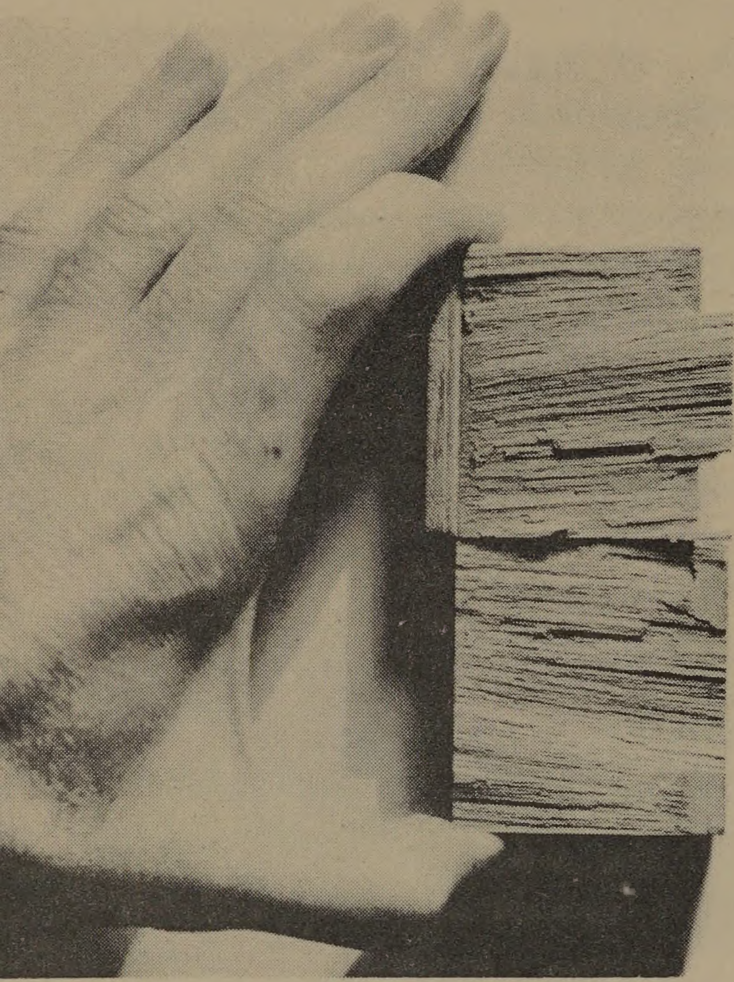
Average values based on tests of a number of specimens are used in this grouping of species. By carefully eliminating the poorer lightweight pieces, a large part of some species such as ash can be put into the next higher group. It follows, also, that the utility of species in the lower groups may be enhanced by using a

greater number or larger size of nails or screws than is required for group 3 woods.

Group 1	Group 2		Group 3
Basswood	Ash	Magnolia	Beech
Cottonwood	Blackgum	Maple, soft	Hickory
Willow	Elm, soft	Tupelo	Oak, red
Yellow-poplar	Hackberry	Sycamore	Oak, white
	Sweetgum		Pecan



GLUING



SATISFACTORY JOINTS can be produced in all the southern hardwoods tested with either animal, casein, or vegetable (starch) glue, but some species, usually the denser ones, require more care than others in regulating the gluing conditions to avoid weak joints.

Group 1 woods, for example, demand the most careful control of gluing conditions to obtain joints that, when tested, will break entirely in the wood.

In Group 2 woods satisfactory joints will result over a somewhat wider range of gluing conditions, while Group 3 woods require still less strict control. Starved joints with animal glue, for instance, need be feared in this group only when the temperature of the room and wood is high, the glue thin, and the assembly time short.

It is recommended that the gluing conditions be regulated according to the requirements of Group 1 woods. These conditions will produce good results on all the southern hardwoods. A complete discussion of good gluing practice will be found in U. S. D. A. Bulletin 1500, entitled "The Gluing of Wood." (Government Printing Office, Washington, D. C., 25 cents).

Group 1		Group 2	Group 3
Beech	Magnolia	Ash	Hackberry
Elm	Oak, red	Basswood	Willow
Gum, black	Oak, white	Cottonwood	
Gum, red	Sycamore	Maple, soft	
Hickory	Tupelo	Pecan	
		Poplar, yellow	

ODOR & TASTE

BUTTER, more susceptible to taints than any other food product, when used as the test medium by a dairy expert, disclosed that several southern hardwoods, in addition to the favorites, ash and yellow-poplar, are suitable for food containers from the taste and odor standpoint. Taking ash, the best, as 100, the woods rank as follows:

Ash............	100	Elm, soft......	68
Maple, soft....	84	Blackgum.......	64
Hackberry......	83	Cottonwood.....	58
Sycamore.......	80	Magnolia.......	55
Beech..........	73	Sweetgum.......	58
Yellow-poplar..	71		

Properties other than odor and taste must, of course, be taken into account when selecting a wood for food containers, but any pronounced tendency to impart odor or taste is in itself sufficient to bar a wood from use for certain of the more taint-susceptible food products.

IN CONCLUSION

STUDIES SUMMARIZED in the foregoing pages do not by any means cover the entire field. Phases of machining and woodworking problems that have been touched upon thus far, necessarily somewhat lightly, should be gone into much more deeply to discover the best working conditions for all woods and all operations. In addition, there are several other operations, such as boring, mortising, sanding, carving, and finishing. Behind all lies the urgent need for all possible information that will contribute to greater satisfaction in the use of wood and that will help wood hold its own in the new competition that confronts forest industries.

The work dealt with in this booklet is a part of a program of research under way at the U. S. Forest Products Laboratory to aid the public in the use of wood and in the stabilization of the nation's forest-land and forest-industry enterprise. Specific work summarized here on machining and related properties is that of E. M. Davis; on treating, that of J. D. MacLean; on nail and screw holding, that of J. A. Scholten; and on gluing, that of Don Brouse.